

**N 9 2 - 1 5 8 6 0**

**1991  
NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM**

**Marshall Space Flight Center  
The University of Alabama**

**An Overview of the Current Technology Relevant to the Design and Development of the Space  
Transportation Main Engine (STME)**

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<b>Contract No:</b>	<b>NGT 01-008-021 The University of Alabama</b>



## NATIONAL LAUNCH SYSTEM (NLS)

The National Launch System (NLS), previously known as Advanced Launch System (ALS), is a joint program of the Department of Defense (DoD) and National Aeronautics and Space Administration (NASA). The program was initiated in July 1987 and was subdivided into several phases. The first phase was completed in August 1988 and the seven contractors participating in it were Martin Marietta, General Dynamics, Boeing, McDonnell Douglas, Rockwell, Hughes, and United Technologies. The Phase II of the NLS program is currently in progress. According to the current planning, NLS should achieve an initial launch capability (ILC) in 1998 and initial operational capability (IOC) in 2000 (References 1 and 2).

NLS has three primary objectives:

1. First, it is envisioned as a family of new generation launch systems, applying both existing and new technology to achieve the desired operability and cost goals, ultimately providing a capability for delivering a range of cargo sizes from approximately 1000 to 220,000 lbs., to low earth orbit.
2. Second, ALS deployment will enable deployment of an ambitious Strategic Defense Initiative (SDI) architecture or a Lunar and Mars infrastructure program-a feat that is physically and fiscally unattainable with current systems.
3. Third, and equally important, current launch vehicle programs such as Titan, Delta, and Atlas, will clearly benefit from ALS advanced technologies that will yield cost reductions, increased capacity, and improved overall system performance.

The NLS program is cost-optimized rather than performance-optimized and will utilize advanced technology and innovative management and design approaches to achieve an ambitious, congressionally mandated cost goal of \$300/lb to low earth orbit by the year 2005.

### Concepts for the Reference Vehicles

Several basic concepts were identified for the reference vehicles at the end of phase I of the NLS program. Each of these concepts uses a common cryogenic (liquid oxygen and hydrogen) core engine called Space Transportation Main Engine (STME) being developed by the Marshall Space Flight Center (MSFC).

The three contractors involved in the design and development of STME are: Aerojet,

The three contractors involved in the design and development of STME are: Aerojet, Pratt & Whitney, and Rocketdyne.

The tasks assigned to each of these contractors are indicated below:

- Electromechanical Propellant Control, (Aerojet)
- Engine Controller Development, (Aerojet)
- Full Scale Split Expander Contract, (Not Awarded)
- LOX Turbopump, (Pratt & Whitney)
- Liquid Hydrogen Turbopump (Aerojet)
- Liquid Fuel Turbopump, (Rocketdyne)
- Main Injector Thrust Chamber, Nozzle, and Gas Generator, (Aerojet)
- Subscale and Large Scale Thrust Chamber, (Rocketdyne)
- Large Scale Injector, (Aerojet, Rocketdyne, Pratt & Whitney)

#### The Current Summer Project

The project described in this report was undertaken by the author as a part of the NASA/ASEE Summer Faculty Fellowship Program 1991, for the Thermal Analysis Branch (ED64) of NASA, Marshall Space Flight Center, Alabama. The duration of the project was ten weeks (June 3-August 9, 1991).

The development of the STME being in its early stage, it was decided that the objective of this ten week summer project should be to review the latest literature relevant to STME. It was also decided that this literature search and review should be directed toward the specific topics of interest to the Thermal Analysis Branch (ED64), MSFC. Hence, the search was focused on the following engine components:

1. Gas Generator
2. Hydrostatic/Fluid Bearings
3. Seals/Clearances
4. Heat Exchanges

5. Nozzles
6. Nozzle/Main Combustion Chamber joint
7. Main Injector Face Plate
8. Rocket Engine - General

#### The Methodology of the Literature Search

The research was broadly divided as follows:

1. Conference papers
2. Journal papers.

The selection of the time period chosen for this search was influenced by the following two factors:

- a. The ALS/STME program was initiated in July 1987
- b. Limited time available for the summer program (ten weeks).

Hence, the literature scan was targeted to the following time periods:

1. Conference papers (June 1991 - 1986) 6 years
2. Journal papers - approximately from June 1991-1980 about 11 years

At the end of the search process, approximately about 150 papers were identified as being relevant to the components indicated earlier. The distribution of the papers/models are shown below:

Components	No. of Papers/Models
Gas Generator	7
Hydrostatic/Fluid Bearings	25
Seals/Clearances	22
Heat Exchangers	17
Nozzles	32
Nozzle/Main Combustion Chamber Joint	2
Main Injector Face Plate	2
Rocket Engines-General	42
Total	149

The majority of the papers/models indicated above are found in the following journals/conferences:

- 1) Journal of Space Craft & Rockets
- 2) Transactions of the ASME-Journal of Heat Transfer
- 3) International Journal of Heat and Mass Transfer
- 4) AIAA/ASME/SAE/ASEE Joint Propulsion Conference
- 5) AIAA Aerospace Sciences Meeting

A report with brief reviews of some of these papers/models is available at the Thermal Analysis Branch (ED64) of MSFC.

## REFERENCES

1. Stofan, A.J. & Isakowitz S.J. "Design Challenges for the Advanced Launch System." AIAA-89-2748, AIAA/ASME/SAE/ASEE, 25th Joint Propulsion Conference, Monterey, CA. July 10-12, 1989
2. Wolfe, M.G. "Joint DoD/NASA Advanced Launch System: Pathway to Low-Cost, Highly Operable Space Transportation." Space Commercialization Launch Vehicles and Programs. Edited by Shahrokhi et al. Progress in Astronautics and Aeronautics. Vol. 126, 1990. ISBN 0-930-403-75-4 (AIAA)